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ORIGINAL ARTICLE

Evaluation of sarcopenia in patients with distal radius fractures

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Abstract

Summary Sarcopenia is more prevalent in patients with distal radius fracture (DRF) than in age- and sex-matched controls. Lower appendicular mass index in men and weaker grip strength in both men and women increase the likelihood of DRF.

Introduction Sarcopenia is a core component of physical frailty that predisposes older people to falls and negatively impacts the activities of daily living. The objectives of this study were to compare the prevalence of sarcopenia in patients with DRF with that in age- and sex-matched controls without DRF; and evaluate the association between sarcopenia and the occurrence of DRF.

Methods We prospectively recruited 132 patients over 50 years of age who sustained DRF due to fall and 132 age- and sex-matched controls without DRF. A definition of sarcopenia was based on the consensus of the Asian Working Group for Sarcopenia. Sarcopenic components including appendicular lean body mass, grip strength, and gait speed were compared between the two groups. Other factors assessed for the occurrence of DRF were age, gender, body mass index (BMI), lumbar, and hip bone mineral density (BMD) values. A conditional logistic regression analysis was conducted to evaluate the associations between sarcopenia and the occurrence of DRF.

Results A total of 39 (30%) of 132 DRF patients were sarcopenic, whereas 23 (17%) of the 132 controls were within the sarcopenic criteria ($p = 0.048$). The patient group had significantly lower lean body mass and weaker grip strength than those of the control group. However, there was no significant difference in gait speed between the two groups. According to regression analysis, lower appendicular mass index in men was associated with an increased incidence of DRF (odds ratio [OR] = 0.84, 95% confidence interval [CI] = 0.72, 0.95) while weaker grip strength and lower total hip BMD values were associated with the occurrence of DRF in both men (OR = 0.77, 95% CI = 0.63, 0.92; and OR = 0.79, 95% CI = 0.64, 0.94, respectively) and women (OR = 0.78, 95% CI = 0.64, 0.93, and OR = 0.73, 95% CI = 0.52, 0.92, respectively).

Conclusions Sarcopenia is more prevalent in patients with DRF than in age- and sex-matched controls. Lower appendicular mass in men, weaker grip strength, and lower hip BMD in both men and women increase the likelihood of DRF.

Keywords Distal radius fracture · Sarcopenia · Osteoporosis · Lean body mass · Grip strength

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Introduction

Distal radius fractures (DRF) is the most common upper extremity fracture in older people with higher overall incidence in women and cause a serious public health concern [1, 2]. The incidence of these fractures has been rising in recent decades; a study from the USA found a 17% increase in the incidence of this injury over a 40-year period [3], while the incidence in Sweden almost doubled for the older population over a 30-year time span [4]. DRF usually results from a fall during daily activities in susceptible individuals [5]. Patients with DRF have higher incidence of underlying osteoporosis [6], and it is associated with increased fracture severity and higher incidence of early instability [7], However, bone mineral density (BMD) does not always accurately reflect nonvertebral fracture risk and up to 50% of those who sustain fragility fractures do not have osteoporosis [8], suggesting that factors other than bone mass can influence the risk of DRF.

Sarcopenia, a term used to describe the loss of skeletal muscle mass and consequent loss of muscle function with aging, is known to affect older individuals by decreasing activities of daily living and increasing frailty to falls [9, 10]. In general, maximum muscle mass is observed between the ages of 20 and 30 years in men and women, and muscle mass gradually decreases with age [11]. The decline in total muscle mass between the ages of 40 and 80 has been estimated to be ranging from 30 to 60%, and this is associated with significant disability and morbidity [12]. The prevalence of sarcopenia is reportedly to be as high as 24% in people 65 to 70 years old, and some individuals may lose up to 15% of total muscle mass during the seventh or eighth decade of life [13, 14]. Falls and functional impairments are known to be linked to sarcopenia [15]. They might also increase the risk of fractures [16]. However, some studies have shown contradictory results regarding the relationship between the presence of sarcopenia and the occurrence of fragility fracture in the older population [17, 18].

Although sarcopenia frequently occurs with osteoporosis, it is an independent phenomenon that might compound the risk of fragility fractures considering its link to fall risk in older population [17]. Some studies have investigated sarcopenia in patients with orthopedic injury [19]. However, little attention has been paid to the effect of sarcopenia on the occurrence of DRF, one of the most common fragility fractures. Therefore, the primary objective of this study was to determine the prevalence of sarcopenia in patient with DRF compared to that in age- and sex-matched controls and evaluate the association between sarcopenia and the occurrence of DRF. The secondary objectives were to investigate whether sarcopenic measurements could independently predict the occurrence of DRF and to identify other independent predictors of DRF in population older than 50 years of age. We hypothesized that sarcopenia was associated with bone fragility and the occurrence of DRF.

Patients and methods

This study had appropriate ethical approval, and all patients gave written informed consent. We prospectively recruited patients with DRF who were treated surgically or nonsurgically at our institution from July 2014 to March 2016. These patients were recruited from a tertiary care university hospital serving as a regional emergency trauma center. Inclusion criteria were acute DRF treated within 2 weeks after injury caused by minor trauma such as fall on an outstretch hand with patients older than 50 years of age who agreed to participate in the study. Patients were excluded if they had associated systemic or multiorgan injuries, cognitive impairment, or medical condition such as neuromuscular disease of chronic debilitating disease that might affect muscle strength (renal insufficiency, adrenal insufficiency, rheumatoid arthritis, thyroid disease, parathyroid disease, or Parkinson disease). Controls were selected from patients who visited the health care center of our hospital for regular health examination in the same study period. Control group included patients without any wrist symptoms or disease. They were age- and sex-matched with patient with DRF. They consented to grip strength and gait speed evaluation with skeletal muscle mass measurement. All controls did not have any specific disease entities except general medical conditions such as hypertension and diabetes.

The definition of sarcopenia was based on the proposal from the Asian Working Group for Sarcopenia (AWGS) [20]. Participants were classified as sarcopenic if they had low lean mass plus slowness (classified according to gait speed) or weakness (assessed according to grip strength). Participants underwent whole-body Dual-energy X-ray absorptiometry (DXA) (DISCOVERY-W fan-beam densitometer; Hologic Inc., MA, USA) to assess of BMD and body composition. Body compositions such as bone mass, fat mass, and lean soft tissue mass were determined from the absorption rate of each X-ray beam. Low lean mass was defined by adjusting appendicular lean mass, the sum of muscle mass in arms and legs, by the height (ASM/Ht^2, Kg/m^2). AWGS [20] has suggested the cut-off points of ASM/Ht^2 to be 7.0 kg/m^2 in men and 5.4 kg/m^2 in women of Asian origin. BMD was classified by the World Health Organization criteria based on the T score of the lumbar spine (L1-4) and/or femoral neck and/or total hip as follows: normal, T score > −1.0 SD; osteopenia, −1.0 ≥ T score > −2.5 SD; and osteoporosis, T score ≤ −2.5 SD [21]. Young Caucasian women were used as the reference population in men and women, as the International Society for Clinical Densitometry recommends [22]. Vertebrae that were fractured otherwise nonevaluable were excluded from analysis of lumbar spine bone density scans. Walking speed was calculated as the average of two usual walking pace attempts over 6 m and expressed as m/s. Slowness was defined as gait speed slower than 0.8 m/s [20]. The grip strength of the unaffected hand was measured with a Jamar dynamometer (Asimow Engineering, Los Angeles, CA, USA) with the elbow flexed at 90° and the forearm in a neutral rotation. The mean values of three trials were recorded in kilograms. For adjustment of hand dominance, the grip strength of the left hand was multiplied by 1.1 according to the simple rule that the dominant hand is approximately 10% stronger than the nondominant hand for right-handed subjects [23]. This rule was not applied to left-handed subjects. Weak hand grip strength is suggested to be defined as <26 kg for men and <18 kg for women [20].

Statistical analysis

A post-hoc power analysis indicated that a sample size of 264 patient (132 per group), would have 75% power to detect a difference in sarcopenia in the fracture (30%) versus the nonfracture group (17%) with a precision of 5%.

Descriptive statistics were calculated to determine patients' demographics and clinical characteristics. Kolmogorove Smirnov test was employed to identify the normality of variable distributions. To determine significant difference between groups for continuous variables, *t* test was used. Chi-square or Fisher's exact test was used to determine significant differences in categorical variables such as the proportion of sarcopenia and incidence of osteoporosis between the two groups. Correlations between all parameters were evaluated with Pearson's correlation test. Pearson coefficient ranging between 0.1 and 0.3 was considered to be weakly correlated. If the coefficient was between 0.31 and 0.6, it was considered as moderately correlated. Pearson coefficient value greater than 0.61 was considered as strongly correlated. Univariate logistic regression analyses were used to analyze the odds ratio (OR) for the occurrence of DRF using age, BMI, lumbar spine BMD, total hip BMD, and sarcopenic measurements as potential risk factors (binary logistic regression, forward conditional method). Each sarcopenic measurement (ASM/ht2, gait speed, and grip strength) was included as a potential predictor for occurrence of DRF in the regression analysis. Next, a multivariate analysis was performed to find independent factors for the occurrence of DRF using a multiple logistic regression analysis and to adjust confounding effects between potentially independent predictors. Variables with p values less than 0.1 in univariate analyses were considered as potentially independent variables in a multivariate analysis. Femoral neck BMD was excluded from the logistic analysis because this variable was strongly correlated ($r = 0.81$) with total hip BMD.

Results

A total of 39 (30%; 34% in men, 27% in women) of the 132 DRF patients were sarcopenic, whereas 23 (17%; 15% in men, 19% in women) of the 132 controls were within the sarcopenic criteria ($p = 0.048$). The DRF patient group had significantly lower lean body mass and weaker grip strength than the control group ($p = 0.040$ and 0.007, respectively). However, there was no significant difference in gait speed between the two groups. The DRF patient group had significantly lower BMD values at femoral neck and total hip than the control group (both $p < 0.001$). However, lumbar spine BMD was not significantly different between the two groups (Table 1).

Appendicular lean body mass index was negatively correlated with age ($r = -0.415$, $p < 0.001$), but positively correlated with grip strength ($r = 0.502$, $p < 0.001$), femoral neck BMD ($r = 0.450$, $p = 0.009$), and total hip BMD ($r = 0.461$, $p = 0.006$, Table 2). Grip strength was negatively correlated with age ($r = -0.403$, $p = 0.001$), but positively correlated with BMI ($r = 0.345$, $p = 0.023$), femoral neck BMD ($r = 0.450$, $p = 0.009$), and total hip BMD ($r = 0.461$, $p = 0.006$). Gait speed was correlated only with age ($r = 0.392$, $p = 0.012$).

Table 1 Demographic and clinical characteristics of participants

	Patient group (n = 132)	Control group (n = 132)	p
Age, y	62.4 ± 7.2	62.1 ± 7.3	
Gender (male, female)	41:91	41:91	
BMI, kg/m^2	22.9 ± 2.6	23.3 ± 2.9	
- Sarcopenia diagnosed	39 (30%)	23 (17%)	0.048
	Men 14/41 (34%)	Men 6/41 (15%)	0.039
	Women 25/91 (27%)	Women 17/91 (19%)	0.159
Appendicular mass index (kg/m^2)	6.14 ± 1.1	6.43 ± 1.2	0.040
Grip strength (kg)	17.4 ± 4.7	19.2 ± 6.1	0.007
Gait speed (m/s)	0.86 ± 0.25	0.90 ± 0.23	0.185
- Osteoporosis diagnosed	59 (45%)	33 (30%)	0.043
Lumbar BMD (g/cm^2)	0.98 ± 0.12	1.01 ± 0.14	0.061
Femoral neck (g/cm^2)	0.74 ± 0.10	0.80 ± 0.16	<0.001
Total hip (g/cm^2)	0.84 ± 0.09	0.90 ± 0.18	<0.001

Values are expressed with mean ± SDs or number of cases (proportion [%])

BMI body mass index, *BMD* bone mineral density

Table 2 Correlation coefficient (*r*) between parameters in study population

Variables	Age	BMI	Appendicular mass index	Grip strength	Gait speed	Lumbar BMD	Femoral neck BMD
BMI	−.162						
	(.170)						
Appendicular Mass index	**−.415**	**.552**					
	(<.001)	**(<.001)**					
Grip strength	**−.403**	**.345**	**.502**				
	(.001)	**(.023)**	**(<.001)**				
Gait speed	**−.392**	.239	.312	.304			
	(.012)	(.291)	(.129)	(.072)			
Lumbar BMD	**−.339**	**.453**	.170	.312	.254		
	(.048)	**(.007)**	(.337)	(.102)	(.324)		
Femoral neck BMD	**−.435**	**.559**	**.450**	**.342**	.318	**.585**	
	(.012)	**(.001)**	**(.009)**	**(.032)**	(.092)	**(<.001)**	
Total Hip BMD	**−.342**	**.564**	**.461**	**.332**	.308	**.676**	**.870**
	(.045)	**(.001)**	**(.006)**	**(.042)**	(.142)	**(<.001)**	**(<.001)**

Partial correlation was conducted by controlling for gender, and significant correlations are in bold

BMI body mass index, *BMD* bone mineral density

Univariate logistic regression analysis indicated that the *p*-values for age, grip strength, lumbar, and total hip BMD in women (0.02, 0.02, 0.07, and 0.1, respectively) and appendicular mass index, grip strength, and total hip BMD in men (0.05, 0.02, and 0.03, respectively) were less than 0.1 (Table 3). These variables were included in the multivariate regression model. Results of multivariate logistic regression analysis indicated that lower appendicular mass index in men was associated with a higher likelihood of DRF, while weaker grip strength and lower total hip BMD values were associated with the occurrence of DRF in both men and women (Table 3).

Discussion

Several studies have shown contradictory results regarding the relationship between the presence of sarcopenia and the occurrence of fragility fracture in the older population [17, 18]. However, the association between sarcopenia and the occurrence of DRF has not been well evaluated. This study demonstrated that sarcopenia was more prevalent in patients with DRF than in age- and sex-matched controls. Lower appendicular mass index in men was associated with a higher likelihood of DRF, while weaker grip strength and lower hip BMD

Table 3 Logistic regression analyses for factors associated with the occurrence of DRF

Variables	Univariate analysis			Multivariate analysis[a]		
	OR	95% CI	*p*	OR	95% CI	*p*
Women						
Age	0.915	0.880–0.970	0.023	0.902	0.862–0.951	0.012
ASM/height^2	0.952	0.731–1.196	0.185			
Grip strength	0.806	0.672–0.950	0.021	0.783	0.641–0.932	0.011
Gait speed	0.920	0.784–1.109	0.466			
Lumbar BMD	0.897	0.764–1.075	0.072			
Total hip BMD	0.747	0.562–0.942	0.012	0.725	0.522–0.924	0.008
Men						
Age	1.032	0.970–1.119	0.421			
ASM/height^2	0.854	0.745–0.975	0.045	0.835	0.721–0.954	0.022
Grip strength	0.800	0.662–0.945	0.015	0.769	0.631–0.921	0.010
Gait speed	0.977	0.923–1.055	0.430			
Lumbar BMD	0.912	0.792–1.052	0.102			
Total hip BMD	0.808	0.663–0.961	0.031	0.795	0.643–0.942	0.010

Significant predictors have been highlighted

ASM appendicular skeletal mass, *BMD* bone mineral density, *OR* odds ratio, *CI* confidence interval

[a] Covariates significant at the $p < 0.1$ level in univariate analysis were included in the multivariate regression model

were commonly associated with the occurrence of DRF in both men and women.

The prevalence of sarcopenia based on EWGSOP definition varies between 1 and 29% in community-dwelling populations aged over 50 years [24]. The values differ for institutionalized and hospitalized groups and may also vary depending on the operational definition implemented [12]. In this study, the prevalence of sarcopenia in patients with DRF was 34% in men and 27% in women. Because the respective technique and cut-off value used for the measurement of lean body mass are different, it is uncertain whether the differences in prevalence between different studies are related to racial differences.

In this study, the lean body mass index was moderately correlated with femoral neck BMD and total hip BMD, but not with lumbar BMD. Although the correlation coefficients between lumbar BMD values and appendicular mass index were not significant, our results corroborated with the results of previous reports demonstrating substantial interrelationship between sarcopenia and osteoporosis [25, 26]. There are several interrelationships between bone and muscle. When the aging process affects one of these two tissues, the functionality of the other is compromised [27]. Our results are also consistent with previous findings showing that BMD is correlated with lean body mass, especially between femoral neck BMD and skeletal mass index [28].

This study demonstrated that component measures of sarcopenia were associated with the occurrence of DRF. Low grip strength and appendicular mass index revealed significant associations with the occurrence of DRF. However, low gait speed did not show significant associations with the occurrence of DRF. A previous prospective study has reported that a decrease in handgrip strength is associated with an increased risk of major clinical fractures [29]. Although grip strength can be used to assess primarily muscle function in the upper extremity, it has been described as a reasonable surrogate measure for general physical function such as nutritional status, strength of other muscle groups, fatigue, and susceptibility to injury [30, 31]. In the present study, lower appendicular mass index was associated with a higher likelihood of DRF only in men. Despite the fact that sarcopenic women had significant lower bone mass, the association between sarcopenia and the occurrence of DRF could not be explained by sarcopenia, suggesting that factors other than bone or muscle mass may contribute to fracture risk, such as bone quality [32] and physical activity level [33]. Our results are consistent with the previous finding showing that the association between sarcopenia and functional decline is more significant in men than that in women [34, 35]. Further research is needed for therapeutic consideration. We found that there was no significant difference in gait speed between the DRF group and the control group. Studies concerning risk factors of distal radial fracture have concluded that distal radial fractures do not tend to occur in individuals exhibiting poorer physical performance [36, 37]. Silman [36] has found that women who walk regularly have a higher risk of distal radial fracture than those who do not walk regularly. Kelsey et al. [37] have found that patient-reported difficulty in performing physical functions is associated with decreased risk of distal radial fracture. We found that age was not a predictor for the occurrence of DRF in men, while it was in women. The results are in consistent with previous finding by Hong et al. in that age was associated with an increased risk of wrist fracture only in women [17]. Brogren et al. noted that the incidence of women increased rapidly from 50 years of age and older while that in men remained low until 80 years of age, but despite this increase still remained significantly lower than the rates seen in women [38]. In this regard, further research may be needed to determine whether lifestyle factors or age at menopause affect the occurrence of DRF. In terms of bone mineral density, the occurrence of DRF was found to be significantly related to hip BMD but not lumbar spine in this study, in agreement with previous finding showing that the severity of DRF and cortical thickness of distal radius are not related to lumbar spine BMD (mainly trabecular) [39, 40].

Our study has some limitations. First, the control group was not recruited from the normal healthy population. The general characteristics of those patients who visited the health care center (hospital based controls) were not well validated. Furthermore, our institution is a tertiary referral hospital and the included subjects might have more diseases and injuries. Although we excluded subjects with known chronic medical conditions that might affect muscle mass and strength, some of the controls might have been affected by undiagnosed medical conditions. Therefore, a comparison with normal healthy controls might have revealed differences in the levels of other risk factors. Second, the definitions and algorithms of sarcopenia are controversial. Respective technique and cut-off value used for the measurement of lean body mass are different. These definitions may not identify the same individuals. Third, this is a cross-sectional study. The association between sarcopenic measures and falls might not have been causally related. There were limitations in interpreting the relationship. A longitudinal study would be necessary to demonstrate the causality. Fourth, gait speed was assessed using a 6-m walk test whereas it is usually assessed using a 10-m walk test. Although the speeds obtained are likely to be highly correlated, there is some evidence that longer distances may be more appropriate for single assessments [41]. Finally, the patient's lifestyle factors, such as smoking or alcohol intake, education, and physical activity, which may also be related to occurrence of sarcopenia and DRF, were not measured in the present study.

In summary, sarcopenia was more prevalent in patients with DRF than in age- and sex-matched controls. Lower appendicular mass index was associated with a higher likelihood of DRF in men while weaker grip strength and lower hip BMD were commonly associated with the occurrence of DRF in both men and women. Further studies are warranted on whether preventive measures such as muscle strengthening exercise [42] and nutritional supplementation [43] might be helpful for preventing DRF in older people with sarcopenia.

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Compliance with ethical standards

Conflict of interest None.

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